

Chapter 1

Basic scientific principles of physiology

Physiology is the study of how living things function; it differs from anatomy, which studies human form, yet it relies heavily on anatomical and biological concepts. An understanding of the basic principles of physiology is an essential component of any healthcare student's repertoire of understanding. Physiology integrates biology, chemistry, physics and even human behaviour.

The body is a very complex organism and is made up of many components. The smallest of these components is the atom and concludes with the organism itself – organismal level (Figure 1.1).



Question 1

(a) In Figure 1.1, identify the levels of organisation of the body tissue from the atomic level to the organismal level.



(b) At system level (level 5), complete the labels for the following:

- pharynx
- oesophagus
- liver
- stomach
- pancreas
- gallbladder
- small intestine
- large intestine.

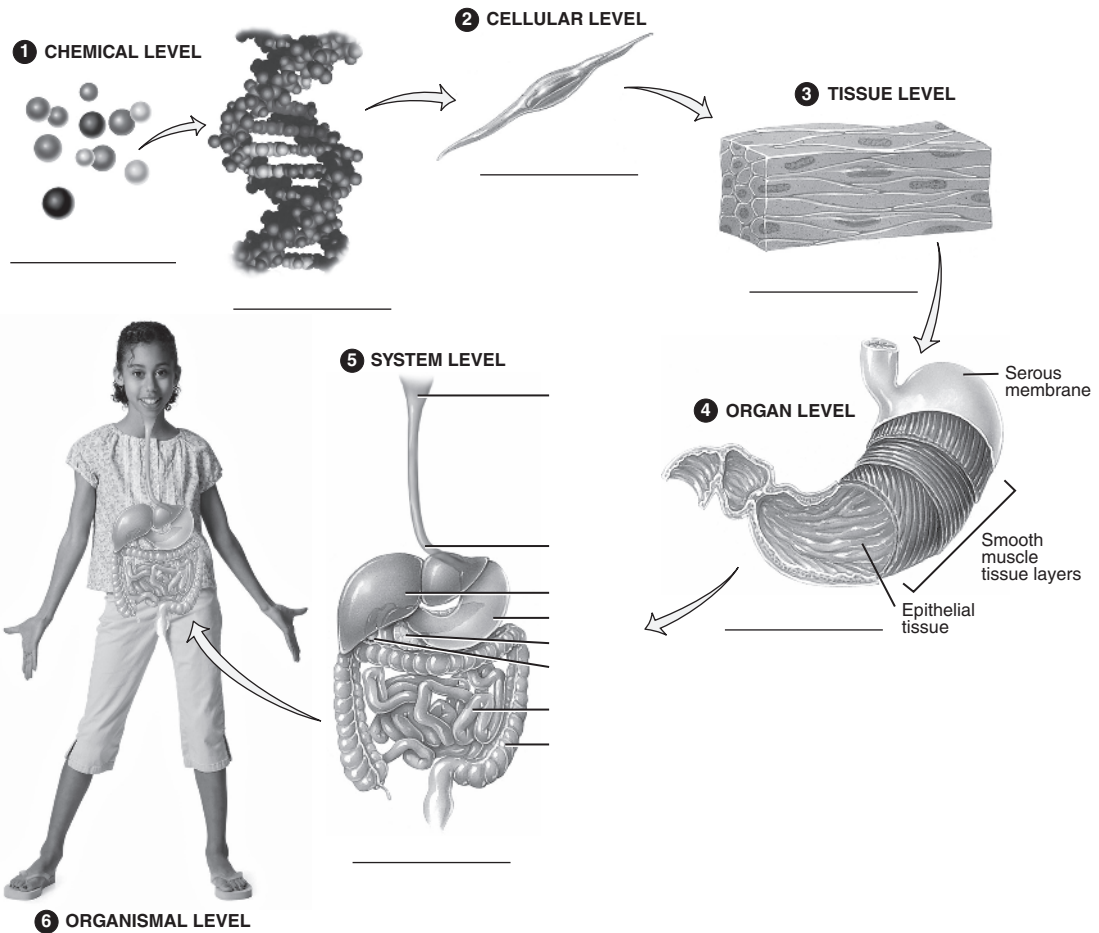


Figure 1.1 Levels of organisation of the body tissue. *Source:* Tortora 2009. Reproduced with permission of John Wiley & Sons.



Question 2 Match the pairs.

The most abundant substance found in the body

Supplies the energy for the organism to fulfil all the essential characteristics compatible with life

Forms 20% of air, is used in the release of energy from the assimilated nutrients

A form of energy that partially controls the rate at which metabolic reactions happen

Two types of pressure that are required by an organism

Atmospheric and hydrostatic

Water

Heat

Oxygen

Food



Question 3 Time yourself to unscramble these words.

Scrambled	Answer
CHAOSTEMPRI	
SYPHIGOYLO	
SONGMAIR	
ATOMBLICE	
LAMIECHBCANI	
REMYSCHIT	
AMTONYA	
UHNAM	

4

**Question 4**

(a) Figure 1.2 shows the components of an atom. Label this diagram with the following labels:

- Proton
- Electron
- Neutron
- Paths of orbit
- Nucleus



(b) Colour in:

- Proton
- Electron
- Neutron
- Nucleus

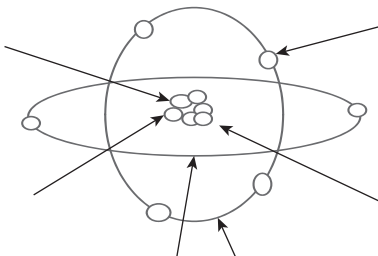


Figure 1.2 Schematic diagram of an atom. *Source:* Peate 2015. Reproduced with permission of John Wiley & Sons.



Question 5 Match the pairs.

Always central

Atoms

The building blocks of life

The nucleus

Carry a positive electrical charge

Electrons

Carry a negative electrical charge

Protons



Question 6 Time yourself to unscramble these words.

Scrambled	Answer
TORPON	
BORTI	
CETRENLO	
VISITOE	
VENEGIAT	
THAP	
LELSH	
DUBLINGI	

Carbon atom

Carbon is a very important atom for life forms, as we are all carbon-based entities. Carbon is used to demonstrate the make-up of an actual atom.

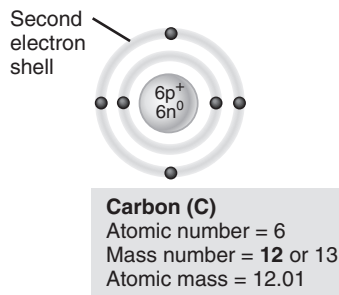


Figure 1.3 Carbon atom. *Source:* Peate 2015. Reproduced with permission of John Wiley & Sons.



Question 7 In Figure 1.4, identify the atomic number for nitrogen.

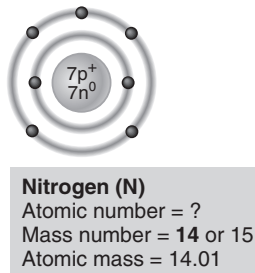


Figure 1.4 Nitrogen atom. *Source:* Peate 2015. Reproduced with permission of John Wiley & Sons.


Question 8 Match the pairs.

The smallest particle of an element or compound

Molecule

The 'attractive' force that holds atoms together

Ions

Atoms with extra electrons or missing electrons

Chemical bonds (ionic, covalent or polar/hydrogen)

Elements

A chemical element is a material that cannot be broken down or changed into another substance using chemical means. Elements are the basic chemical building blocks of matter. There are 117 or 118 known elements. Some common examples of elements found in the body include:

- iron
- hydrogen
- carbon
- nitrogen
- oxygen
- calcium
- potassium
- sodium
- chlorine
- sulphur
- phosphorus


Question 9 Time yourself to unscramble these words.

Scrambled	Answer
BARCON	
RAGECH	
BATSIYLIT	
RATTYLENUI	
TROGENIN	
VACOLENT	
CINIO	
DOGYRHEN	



Question 10 Complete Table 1.1. Identify the chemical symbol representing the elements and also identify those that are metals and non-metals.

Table 1.1 Elements.

Element	Chemical symbol	Metal	Non-metal
Iron			
Hydrogen			
Carbon			
Nitrogen			
Oxygen			
Calcium			
Potassium			
Sodium			
Chlorine			
Sulphur			
Phosphorus			



Question 11 In Figure 1.5, colour in the metals, metalloids and non-metals on the periodic table.

	1																	17	18
1	1 H																	1 H	2 He
2	3 Li	4 Be										5 B	6 C	7 N	8 O	9 F	10 Ne		
3	11 Na	12 Mg	3	4	5	6	7	8	9	10	11	12	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar	
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr	
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe	
6	55 Cs	56 Ba	71 Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn	



Metals



Metalloids



Non-metals

Figure 1.5 The periodic table.


Question 12 Match the pairs.

A pure substance made up of two or more elements chemically bonded together

They donate electrons (to other atoms to make molecules)

They accept electrons (from donor atoms)

They are neither metals nor non-metals – they are sometimes referred to as semi-metals

NaHCO_3

Potassium chloride

KCl

Metalloids

Metals

Non-metals

A compound such as H_2O (water), NaCl (salt), CO_2 (carbon dioxide)

Sodium bicarbonate


Question 13 Time yourself to unscramble these words.

Scrambled	Answer
MOPSITASU	
DELTOILSAM	
DUMPNOOCS	
LAMECHIC	
TEEMLEN	
MYSOBL	
DROIPIEC	
RODNO	

Electrolytes

A development of bonding is the production of electrolytes. These are substances that move to oppositely charged electrodes in fluids. Electrolytes include, for example,

- sodium
- potassium
- calcium
- bicarbonate
- magnesium
- chloride

Electrolytes are particularly important for three things within the body:

1. many are essential minerals
2. control the process of osmosis
3. help to maintain the acid–base balance required for normal cellular activity.



Question 14 Complete Table 1.2 by identifying the difference in conduction of electrical current between strong electrolytes, weak electrolytes and non-electrolytes.

Table 1.2 Types of electrolyte.

Type of electrolyte	Conduction of electrical current
Strong electrolytes	
Weak electrolytes	
Non-electrolytes	

Acid and base (pH)

It is important to understand pH values, along with alkalinity and acidity, as we depend upon the relationship between acidity and alkalinity in order to survive.

- Acids are substances that donate hydrogen ions (H^+) into a solution.
- Alkalis (also known as soluble bases) are substances that donate hydroxyl ions (OH^-) into a solution or accept H^+ ions from a solution.

The pH scale measures how acidic or basic (alkaline) a substance is. The pH scale ranges from 0 to 14. A pH of 7 is neutral. A pH less than 7 is acidic. Pure water is neutral, pH of 7.0. Vinegar and lemon juice, for example, are acidic, whilst laundry detergents and ammonia are basic.



Question 15 Complete Table 1.3, showing whether substances are acidic, alkaline (base) or neutral.

Table 1.3 Acidic, alkaline and neutral substances.

Substance	pH (acidic, alkaline or neutral)
Milk	
Water	
Vinegar	
An orange	
Coconut water	
Salt	
Ammonia	
Tea	
Oven cleaner	
Liquid used in car battery	
Blood	



Question 16

(a) In Figure 1.6, complete the boxes below to indicate neutral, acidic, alkaline, very acidic and very alkaline.



(b) Insert the following substances in the appropriate boxes:

- blood
- sugar
- ammonia
- salt
- vinegar

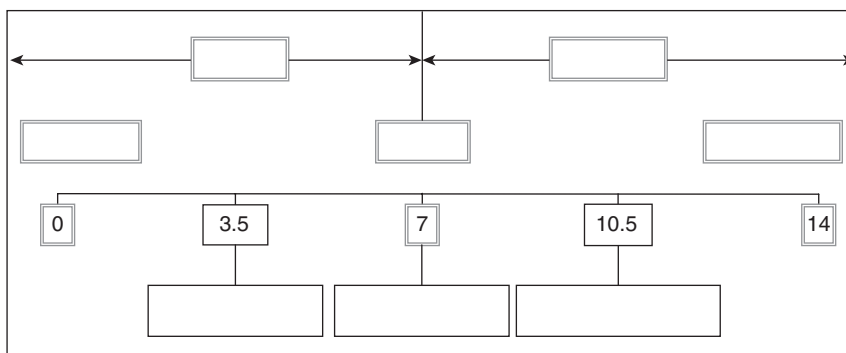


Figure 1.6 Simplified diagram of a pH scale. *Source:* Peate 2011. Reproduced with permission of John Wiley & Sons.


Question 17 Match the pairs.

In a strong acid

In a weak acid

The more OH^- ions (hydroxide ions)

The more OH^- ions

The strength of an acid or alkali is shown using a scale of numbers called the pH scale

only some of the acid molecules form ions

nearly all the acid molecules form ions

the higher the pH number

the numbers go from 0–14

the more alkaline an alkali will be


Question 18 Time yourself to unscramble these words.

Scrambled	Answer
ECLULEMO	
SOSCIDIDATE	
NIMRALES	
BLANCAE	
AILLYTINKA	
UNISTOOL	
DACICI	
TREAVICE	

Homeostasis

Homeostasis refers to the ability of the body or a cell to seek and maintain a condition of equilibrium within its internal environment when dealing with external changes. It is a state of equilibrium for the body allowing the organs of the body to function effectively in a broad range of conditions.

**Question 19**

(a) Identify the stimulus, receptor, control centre and effector on Figure 1.7.

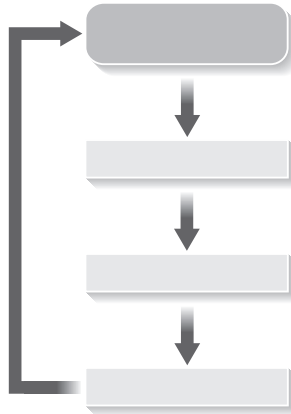


Figure 1.7 Components of a negative feedback system. *Source:* Peate 2015. Reproduced with permission of John Wiley & Sons.

(b) Now use temperature as the stimulus and complete the negative feedback diagram in relation to raised body temperature (Figure 1.8).

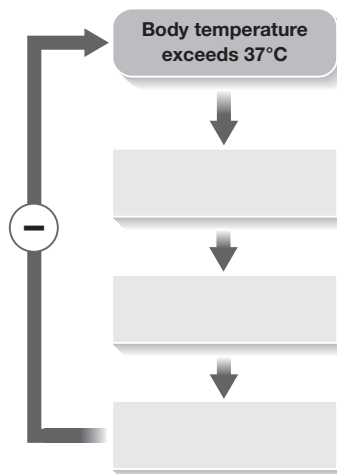


Figure 1.8 Negative feedback of raised temperature. *Source:* Peate 2015. Reproduced with permission of John Wiley & Sons.



(c) In Figure 1.9, place the correct label in each ovals for 1. Stimulus; 2. Receptor; 3. Control centre; 4. Effector; 5. Effector.

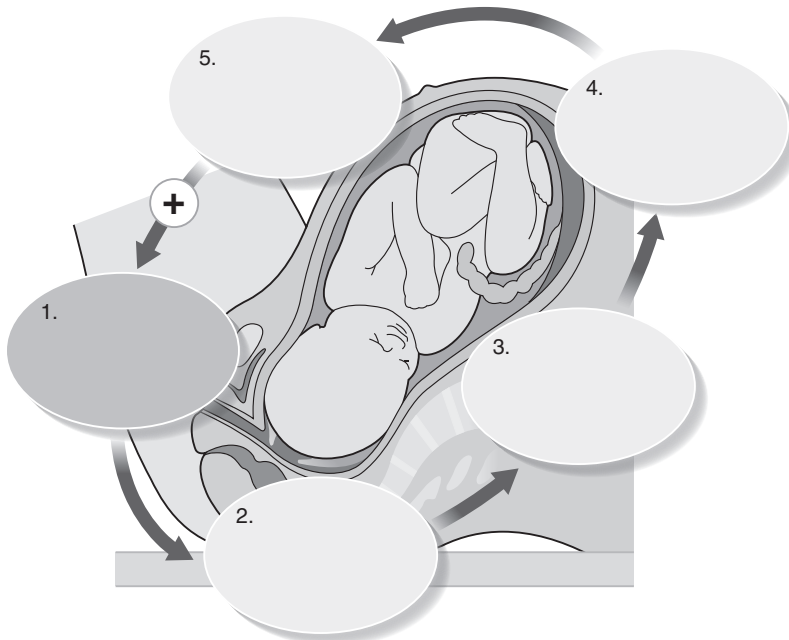


Figure 1.9 Positive feedback of childbirth. *Source:* Peate 2015. Reproduced with permission of John Wiley & Sons.



Question 20 Match the pairs.

Certain nerve endings in the skin sense temperature change

a body system such as the skin, blood vessels or the blood that receives the information from the control centre, producing a response to the condition

The control centre is

something that can elicit or evoke a response in a cell, a tissue, or an organism. A stimulus can be internal or external

An effector is

they detect changes such as a sudden rise or drop in body temperature

Homeostasis is

the brain (the hypothalamus in body temperature regulation)

A stimulus is

a reaction to a specific stimulus

A response is

a state of balance within the body



Question 21 Time yourself to unscramble these words.

Scrambled	Answer
LAXETERN	
MEQUILIRIBU	
MASSIHOOTES	
TROFFECES	
TROVEMENNIN	
KCABDEEF	
LOONTRC	
LIMTUUSS	

Units of measurement

A unit is a standardised, descriptive word specifying the dimension of a number. Properties of matter that have been measured independently of each other are:

- time – measures the duration that something occurs
- length – measures the length of an object
- mass – measures the mass (commonly taken to be the weight) of an object
- current – measures the amount of electric current that passes through an object
- temperature – measures how hot or cold an object is
- amount – measures the amount of a substance that is present
- luminous intensity – measures the brightness of an object.



Question 22 Complete Table 1.4.

Table 1.4 Units of measurement.

Quantity	Name	Symbol
Length	metre	
Mass	kilogram	
Time	second	
Current	ampere	
Temperate	Kelvin	
Amount of substance	mole	
Luminous intensity	candela	

Prefix	Symbol	Meaning	Scientific notation
tera	T		10^{12}
giga	G		10^9
mega	M		10^6
kilo	k		10^3
hecto	h		10^2
deca	da		10^1
deci	d		10^{-1}
centi	c		10^{-2}
milli	m		10^{-3}

1 kilogram = _____ grams
 1 gram = _____ milligrams
 1 milligram = _____ grams
 1 microgram = _____ grams

1 litre = _____ millilitres
 100 millilitre = _____ decilitre
 1 millilitre = _____ microlitres

Snap shot

Body temperature represents heat production and heat loss. If heat generated equals heat lost, the core body temperature will be stable and there will be a state of homeostasis.

1. What are the various sites and methods used for temperature taking?
2. What are the clinical indications for temperature taking?
3. What are the intrinsic factors that may influence temperature?
4. Define hypothermia.
5. Define fever.
6. Define hyperthermia.

Word search

O	I	S	N	O	R	T	U	E	N	S	J	D	D	O	J	L	E	T	Z
J	E	J	H	W	S	A	L	E	L	E	C	T	R	O	N	F	L	M	R
M	K	Y	Y	L	F	V	W	R	R	E	L	F	S	L	O	I	E	C	W
S	F	R	A	F	J	M	B	Z	D	Q	S	S	G	C	N	S	M	Z	V
S	M	T	O	E	D	D	E	C	T	V	T	R	U	E	V	P	E	T	S
A	E	E	L	J	M	C	I	T	A	T	S	O	R	D	Y	H	N	H	P
M	T	G	F	G	W	V	A	X	A	A	C	I	D	H	J	O	T	S	U
C	A	D	C	B	U	O	E	Y	B	B	D	Q	S	G	E	M	C	N	F
K	L	S	A	I	E	F	K	C	Y	C	O	T	Q	X	L	E	W	O	W
E	L	E	C	T	R	I	C	I	T	Y	E	L	A	H	E	O	P	T	S
N	O	V	T	E	M	Q	I	C	N	U	R	U	I	T	C	S	K	O	U
I	I	E	X	A	Q	O	O	N	T	Y	L	C	I	C	T	T	C	R	M
L	D	H	O	M	E	O	S	T	A	S	I	S	Y	U	R	A	A	P	S
A	S	O	U	O	R	H	C	P	I	G	B	J	E	M	O	S	R	Y	I
K	P	M	O	T	A	V	J	X	H	M	H	W	N	O	L	I	B	L	N
L	T	Q	M	L	G	R	M	F	M	E	T	A	L	S	Y	S	O	S	A
A	Y	K	Y	K	B	Z	T	O	M	S	R	T	L	W	T	Y	N	G	G
Z	P	I	K	N	E	O	C	O	W	Z	I	I	M	Z	E	Y	I	O	R
B	S	G	M	E	F	X	Y	D	N	M	X	Y	C	C	S	U	I	E	O
F	B	C	O	T	B	B	I	R	E	T	A	W	Q	F	E	I	M	G	L

ORGANISM

HEAT

TIME

MASS

WATER

ACID

ALKALINE

FOOD

METALLOIDS

METALS

NON

NEUTRON

PROTONS

ELECTROLYTES

ELEMENT

HOMEOSTASIS

ATMOSPHERIC

HYDROSTATIC

ELECTRON

ATOM

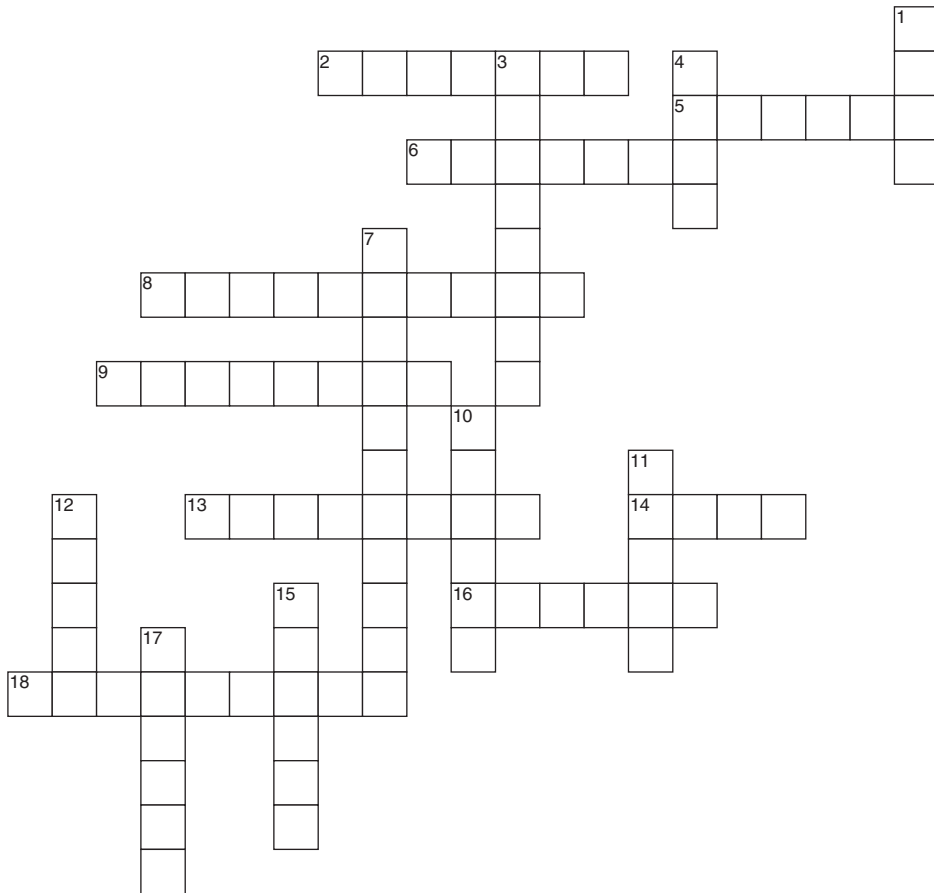
ELECTRICITY

METABOLIC

CARBON

BLOOD

Crossword



Across

2. The combining power of atoms
5. These solutions have pH values more than 7
6. Ions that carry a positive electrical charge
8. The study of how living things function
9. An element with properties of both metals and non-metals
13. This carries a negative electric charge
14. The smallest component of the human body
16. The eighth element of the period table
18. Elements that are neither metals nor non-metals

Down

1. This chemical turns blue litmus paper pink
3. Chemical element with the symbol N
4. Another name for an alkaline substance
7. Maintenance of a stable internal environment
10. This carries a positive electric charge
11. The most abundant substance found in the body
12. Unit of energy
15. Ions that carry a negative electrical charge
17. A very important element for life forms

Fill in the blanks

Use the words in the box to complete the sentences:

(OH⁻), 7, abundant, acid, acidic, acids, air, alkali, atmospheric, atom, atom, atom, atoms, atoms, balance, bases/alkaline, blood, body, body, breathing, broken, carbon-based, cells, changing, charge, chemical, complex, conduct, dissociated, electrolytes, electrons, electrons, element, element, energy, energy, energy, environment, environment, equal, external, fluids, function, function, growth, H⁺, hydrogen, hydrostatic, hydroxyl, independently, interdependent, ionically, ions, ions, metabolic, metals, molecule, molecule, molecules, neutrons, oppositely, organism, organism, organism, oxygen, pH, pH, poor, positive, protons, protons, pure, rate, raw, semi-metals, soluble, stable, structure, structure, structured

1. Anatomy is the study of _____ and physiology is the study of _____. However, _____ is always related to function because the structure determines the _____, which in turn determines how the body/organ is _____ – the two are _____.
2. The _____ is a very _____ organism which consists of many components, starting with the smallest of them – the _____ – and concluding with the _____ itself.
3. Water is the most _____ substance in the _____. Food supplies the _____ for the _____. It also supplies the _____ materials for _____. _____ forms 20% of _____ and is used in the release of _____ from the assimilated nutrients. Heat is a form of _____ that partly controls the _____ at which _____ reactions occur. There are two types of pressure that are required by an _____ : _____ pressure, which is important in the process of _____, and _____ pressure, which keeps the _____ flowing through the body.
4. The smallest building block of the body is the _____. An atom consists of _____, _____ and _____. Carbon is a very important _____ for life forms, as we are all _____ entities. A _____ is the smallest particle of an _____ or compound which exists _____. It contains _____ that have bonded together. The formation of chemical bonds also results in the release of _____ previously contained in the _____.
5. An ion is an atom or a _____ in which the total number of _____ is not _____ to the total number of _____ – hence the atom or molecule has a net _____ or negative electrical _____.
6. Electrolytes are substances that move to _____ charged electrodes in _____. If _____ that are bonded together _____ are dissolved in water within the body _____, they undergo a process where the _____ separate; they become _____. These ions are now known as _____.

7. A chemical _____ is a _____ chemical substance which cannot be _____ down into anything simpler by _____ means. Metals _____ heat and electricity. Non-metals are _____ conductors of heat and electricity. Metalloids are neither _____ nor non-metals – they are sometimes referred to as _____.
8. An _____ is any substance which donates _____ ions (H^+) into a solution. An _____ (also known as a _____ base) is any substance which donates _____ into a solution or accepts _____ ions from a solution. Solutions with a _____ lower than 7 are _____, and those with a _____ greater than _____ are _____ / _____. The further away from a pH of 7 a solution becomes the more _____ or alkaline it is.
9. Homeostasis is the body's attempt to maintain a _____ internal _____ by achieving _____. The body is normally able to achieve a relatively stable internal _____ even though the _____ environment is constantly _____.

Multiple choice questions

1. The ionisation of NaCl
- (a) Is an enzymatic reaction
 - (b) Has no impact on pH
 - (c) Produces a cation (Na^+) and an anion (Cl^-)
 - (d) Causes acidosis
2. What is true of iodine and radioactive iodine?
- (a) They both have the same atomic numbers
 - (b) None have an atomic mass
 - (c) Neither has electrons
 - (d) Both create a biohazard
3. Which of the following is not true of sodium?
- (a) It is called the non-potassium ion
 - (b) It has more protons than electrons
 - (c) It is measured by volume
 - (d) It is measured by pH
4. What is true of water?
- (a) It is a molecule
 - (b) It is an aqueous solvent
 - (c) It is a compound
 - (d) All of the above

5. Which of the following best describes ATP?
- (a) It is a buffer, adding K^+ to a solution
 - (b) It is an energy transfer molecule
 - (c) It is an enzyme
 - (d) It is measured by light
6. Out of the following which has donated an electron?
- (a) ATP
 - (b) Cl^-
 - (c) Na^+
 - (d) HCO_3^-
7. The building blocks of life are known as:
- (a) Enzymes
 - (b) Proteins
 - (c) Atoms
 - (d) All of the above
8. Which of the following carries a positive electrical charge?
- (a) Enzymes
 - (b) Proteins
 - (c) Atoms
 - (d) Protons
9. Which of the following carries a negative electrical charge?
- (a) Electrons
 - (b) Proteins
 - (c) Atoms
 - (d) Protons
10. What is the chemical notation for potassium chloride?
- (a) KCl
 - (b) Cl
 - (c) NaCl
 - (d) Ca

References

- Peate, I. and Nair, M. (2011) *Fundamentals of Anatomy and Physiology for Student Nurses*. Oxford: John Wiley & Sons, Ltd.
- Peate, I. and Nair, M. (2015) *Anatomy and Physiology for Nurses at a Glance*. Oxford: John Wiley & Sons, Ltd.
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